

On the decay of neutral kaons

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Abstract

It is shown that the data on the decay of neutral kaons may be explained without CP-violation.

As known [1] strange K^0 and \bar{K}^0 mesons do not possess certain lifetimes relative to the weak decays, since weak interactions do not conserve the strangeness number. There exist two independent linear combinations of K^0 and \bar{K}^0

$$K_S^0 = K^0 - \bar{K}^0 \quad (1)$$

$$K_L^0 = K^0 + \bar{K}^0 \quad (2)$$

They correspond to the particles with the lifetimes $\tau_S = 8.9 \times 10^{-11}$ s and $\tau_L = 5.2 \times 10^{-8}$ s respectively. The states K_S^0 and K_L^0 are of CP-invariance with the eigenvalues +1 and -1 respectively. K_S^0 decays into the system of two pions

$$K_S^0 \rightarrow \pi\pi \quad (3)$$

with the CP-eigenvalue +1, and K_L^0 decays into the system of three pions

$$K_L^0 \rightarrow \pi\pi\pi \quad (4)$$

with the CP-eigenvalue -1.

K^0 is considered as a superposition of K_S^0 and K_L^0

$$|K^0\rangle = \frac{1}{\sqrt{2}}(K_S^0 + K_L^0). \quad (5)$$

Evolution of K^0 is given by

$$|K^0(t)\rangle = \frac{1}{\sqrt{2}}(K_S^0 e^{-t/2\tau_S} + K_L^0 e^{-t/2\tau_L}). \quad (6)$$

One can expect that, within the time $t < \tau_S$, K^0 decays into two pions, and within the time $\tau_S < t < \tau_L$, K^0 decays into three pions. But, within the time $\tau_S < t < \tau_L$, there exists the probability of the decays of K^0 into two pions

$$\frac{\Gamma(K^0(\tau_S < t < \tau_L) \rightarrow \pi^+\pi^-)}{\Gamma(K^0(\tau_S < t < \tau_L) \rightarrow all)} \approx 2 \times 10^{-3} \quad (7)$$

$$\frac{\Gamma(K^0(\tau_S < t < \tau_L) \rightarrow \pi^0\pi^0)}{\Gamma(K^0(\tau_S < t < \tau_L) \rightarrow all)} \approx 10^{-3}. \quad (8)$$

Decays $K^0 \rightarrow \pi\pi$ within the time $\tau_S < t < \tau_L$ are treated as CP-violation.

K^0 decays in combination with \bar{K}^0 . The state of K^0 is defined by the probabilities of decay of K^0 in combinations with $+\bar{K}^0$ and $-\bar{K}^0$. The state of K^0 embedded in the $K^0\bar{K}^0$ vacuum is given by

$$|K^0\rangle = \left(1 - \frac{\tau_S}{\tau_L}\right)^{1/2} K_S^0 + \left(\frac{\tau_S}{\tau_L}\right)^{1/2} K_L^0. \quad (9)$$

In view of eqs. (1), (2), the decay of K_S^0 leads to the birth of K_L^0

$$K_L^0 = K^0 - K_S^0, \quad (10)$$

and the decay of K_L^0 leads to the birth of K_S^0

$$K_S^0 = K^0 - K_L^0. \quad (11)$$

Hence evolution of K^0 is given by

$$|K^0(t)\rangle = \frac{1}{\sqrt{2}} \left\{ \left(1 - 2\frac{\tau_S}{\tau_L}\right)^{1/2} \left[K_S^0 e^{-t/2\tau_S} + (1 - e^{-t/\tau_S})^{1/2} K_L^0 e^{-t/2\tau_L} \right] + \left(2\frac{\tau_S}{\tau_L}\right)^{1/2} \left[K_L^0 e^{-t/2\tau_L} + (1 - e^{-t/\tau_L})^{1/2} K_S^0 e^{-t/2\tau_S} \right] \right\}. \quad (12)$$

In view of eq. (12), within the time $t < \tau_S$, the number of K^0 decayed into two pions is estimated as

$$\frac{\Gamma(K^0(t < \tau_S) \rightarrow \pi\pi)}{\Gamma(K^0(t < \tau_L) \rightarrow all)} = \frac{1}{2} - \frac{\tau_S}{\tau_L}. \quad (13)$$

Within the time $\tau_S < t < \tau_L$, the number of K^0 decayed into two pions is estimated as

$$\frac{\Gamma(K^0(\tau_S < t < \tau_L) \rightarrow \pi\pi)}{\Gamma(K^0(\tau_S < t < \tau_L) \rightarrow all)} = 2\frac{\tau_S}{\tau_L} = 3.4 \times 10^{-3}. \quad (14)$$

The above consideration allows to explain data on the decay of K^0 without CP-violation.

References

- [1] E.D. Commins, P.H. Bucksbaum, *Weak interactions of leptons and quarks* (Cambridge University Press, 1983)